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CERTIFICATE

This certificate is issued in support of an application for Patent registration in a country outside New Zealand pursuant to the Patents Act 1953 and the Regulations thereunder.

I hereby certify that annexed is a true copy of the Provisional Specification as filed on 24 September 2003 with an application for Letters Patent number 528434 made by HENLEY INDUSTRIES LIMITED.

Dated 1 October 2004.

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528434

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PROVISIONAL SPECIFICATION

IMPROVED AERATOR AND MIXER

We, HENLEY INDUSTRIES LIMITED, a New Zealand company, C/- Tait Ward Adams, 65 Don Street, Invercargill, New Zealand, do hereby declare this invention to be described in the following statement:

TITLE: Improved Aerator and Mixer

Technical Field

The present invention relates to improvements in the aerator/mixer disclosed in New Zealand patent application No. 508044, and to an improved diffuser for an aerator/mixer.

The device of the present invention has been designed especially for aeration and mixing of wastewater, and will be described with particular reference to this application. However, it will be appreciated that the device of the present invention could be used in a wide range of other applications where aeration and/or mixing are required.

Background of the Invention

One known design of aerator/mixer in use at present consists of a rotatable hollow drive shaft with air intake ports at one end, open at the other end, and a propeller adjacent said other end. In use, the aerator/mixer is mounted with the propeller immersed in the wastewater or other liquid to be aerated/mixed, but with the air intake ports above the water line.

The drive shaft is rotated (e.g. by an electric motor) to drive the propeller. The rotation of the propeller mixes the liquid in which the propeller is immersed, and also induces a fluid flow across the lower, immersed, end of the drive shaft. This creates an area of reduced pressure at the lower end of the drive shaft, and hence a similar reduction of pressure at the air intake ports, drawing atmospheric air into the ports and down the shaft.

The air so drawn into the shaft is released as small air bubbles into the liquid flow pattern created by the propeller.

In wastewater treatment processes, aeration introduces air into a liquid, providing an aerobic environment for microbial degradation of organic matter. The purpose of aeration is two-fold:

1. To supply the required oxygen for metabolizing micro-organisms.

2. To provide mixing so micro-organisms come into intimate contact with the dissolved and suspended organic matter.

Disclosure of the Invention

An object of the present invention is to provide a diffuser for an aerator/mixer which improves the efficiency of the aerator/mixer. A further object of the present invention is the provision of an aerator/mixer of improved efficiency, and which is capable of increasing the volume of air which is provided by the apparatus, without a significant increase in the power consumption.

The present invention provides a diffuser which consists of a cylinder open at one end and closed at the opposite end, the open end of the cylinder being securable to an air supply; the wall of the diffuser being formed with a plurality of holes through the thickness of the wall, each hole being circular or elliptical in plan and being tapered in diameter such that each hole is greater in diameter at the outer surface of the wall of the diffuser than at the inner surface of the wall of the diffuser.

Preferably, each said hole is inclined at predetermined angles relative to both the longitudinal axis of the diffuser and the radius of the diffuser.

The present invention further provides an aerator/mixer which includes: a rotatable hollow drive shaft with at least one air intake port at or adjacent one end thereof and a propeller mounted adjacent the other end thereof so as to be rotatable with the drive shaft; means for rotating the drive shaft and the propeller; means for supplying air as above atmospheric pressure to the or each said air intake port; and air permeable diffuser mounted on said other end of the drive shaft, with the interior of the diffuser in communication with the interior of said hollow drive shaft; the end of the diffuser remote from the drive shaft being closed, and the side wall of the diffuser being formed with a plurality of holes, such that air supplied to the or each said intake port can exit from the other end of the drive shaft only through said holes; each said hole being circular or elliptical in plan and being tapered such that the diameter of the hole at the outer surface

of the diffuser wall is greater than the diameter of the hole at the inner surface of the diffuser wall; the propeller being further from said other end of the drive shaft than said diffuser.

Brief Description of the Drawings

By way of example only, a preferred embodiment of the present invention is described in detail, with reference to the accompanying drawings, in which:-

Figure 1 is a diagrammatic side view of an aerator/mixer in accordance with the present invention;

Figure 2 is a detail of the circled portion of figure 1 on a larger scale;

Figure 3 is a detail of the lower portion of figure 1, on a larger scale;

Figure 4 is a detail of figure 3 on a larger scale;

Figure 5 is an enlarged view of the circled portion of figure 4; and

Figure 6 is an enlarged cross-sectional view taken on the line VI - VI of Figure 4.

Best Mode for Carrying Out the Invention

Referring to Figure 1 the drawings, and aerator/mixer 2 is supported upon a platform 3 by pontoons 4. The aerator/mixer 2 is mounted upon the platform 3 by means of support brackets (not shown) which allow the angle of the longitudinal axis of the aerator/mixer relative to the waterline (indicated by line 5) to be adjusted as necessary, and the aerator/mixer to be raised clear of the water for maintenance and repair. The support brackets and the pontoons preferably are of the type described in New Zealand patent application No. 508044.

The aerator/mixer 2 may of course be supported by alternative means such as fixed mountings to bridges or walls.

The pontoons 4 allow the aerator/mixer 2 to float on the surface of the lagoon of tank with the propeller 7 of the aerator/mixer below the surface of the liquid, but the upper part of the aerator/mixer above the surface.

The aerator/mixer 2 comprises an electric motor 8 which is coupled by a no flexible coupling assembly 9 to one end of a hollow drive shaft 10. The propeller 7 is mounted adjacent the other end of the drive shaft 10, and rotates with the drive shaft. Immediately below the propeller 7, at the very end of the drive shaft 10, a diffuser 11 is mounted on, and rotates with, the drive shaft. The diffuser 11 is coaxial with the drive shaft 10 and the hollow interior of the drive shaft 10 opens into the interior of the diffuser 11. The end of the diffuser 11 remote from the drive shaft 10 is closed and has a rounded nacelle 11a secured over it. The nacelle 11a has a smoothly rounded aerodynamic shape which promotes laminar flow of the liquid past the diffuser, and reduces turbulence in the liquid. The nacelle is made of a lightweight abrasion resistant material.

The drive shaft 10 is surrounded by a housing 12 which encloses the coupling 9 and all of the drive shaft up to appoint immediately above the propeller 7. The lower end of the housing 12 optionally is formed with a series of fins 13 equidistant the space around in the circumference of the housing 12 (shown on a larger scale in figure 3). Each fin 13 is wedge-shaped in side view, with the widest portion of the wedge at the end of the housing 12. The slope of each fin preferably is in the range 1:6-1:10; if the fins are too steeply sloped and the aerator/mixer is used in liquid which have a substantial content of solids or other debris, there is a tendency for the fins to "rag up" i.e. for debris to build up along the length of the fin. The end 13a of each fin is rounded, also to reduce ragging up.

The purpose of the fins is to stabilise the water in the area above the propeller 7 so water tends to be drawn on to the propeller in a direction parallel to the longitudinal axis of the aerator/mixer, as indicated by the double headed arrows A in Figure 3. This increases the efficiency of the propeller 7. However, for some applications of the aerator/mixer, it is believed that the aerator/mixer may operate more efficiently without the fins 13, and they can be omitted if necessary.

As shown on a larger scale in Figure 2, a two symmetrically spaced ports 14 are formed around the circumference of the upper end of the drive shaft 10, just below the coupling assembly 9. Each of the ports 14 opens into the interior of the drive shaft 10. An inlet 15 is formed in the wall of the housing 12, aligned with the ports 14. A pipe 16 is connected between the inlet 15 and an air blower 17 of known type, mounted on the platform 3. Any of a wide range of types of blower (or equivalent) may be used.

In use, the drive shaft 10 rotates relative to the housing 12, so a small clearance 18 must be left between the walls of the inlet 15 and the drive shaft 10. However, is important that as little as possible of the air supplied through the inlet 15 passes into the space 19 between the exterior wall of the drive shaft 10 in the interior wall of the housing 12, since any air which passes down in this space enters the liquid above the propeller 7, rather than below it, and this tends to cause cavitation of the liquid and hence damage to the propeller surfaces. The upper portion of the housing 12 may be formed with small vents (not shown) to encourage the venting of any air which does pass into the space 19.

To minimise the air passing into the space 19, two seals 20,21 are mounted on the exterior of the drive shaft 10, just downstream of the inlet 15. The seals 20,21 are mounted between the guide rings 22,23, cast into the outer surface of the drive shaft 10. Each seal 20,21 consists of a strip of highly abrasion resistant material; the seal 20 has its ends one on each side of a cast in rib 24 on one side of the drive shaft 10, and the seal 21 has its ends one on each side of a cast in rib 25 on the opposite side of the drive shaft 10. By mounting the seals on the rotating component (i.e. the drive shaft 10) in use the centrifugal force caused by the rotation of the drive shaft 10 urges the seals 20,21 outwards, pressing the bearing surfaces of the seals against the interior wall of the housing 12. Typically, the seals 20,21 are made of a material capable of coping with rotational speeds of up to 12 m per second; one suitable material has been found to be a woven graphite product marketed as "flexible graphite".

It is important that air passes through the inlet 15 as smoothly as possible, since any change in a direction tends to cause turbulence, which in turn causes pressure losses. To avoid such losses, the pipe 16 is angled to lead smoothly into the interior of the drive shaft 10.

As shown in detail in Figures 3 and 4, the diffuser 11 comprises a cylinder having the same external diameter as the external diameter of the drive shaft 10, the cylinder being open at the end 30 adjacent the drive shaft 10, and closed at the opposite end 31. The internal surface of the end 31 is formed with a turning vane 32 which provides a curved surface which tapers smoothly from a narrow portion 33 adjacent the walls of the diffuser 11 up to a central peak 34 which lies on the longitudinal axis of the diffuser.

It is believed that the precise shape of the turning vane 32 is not critical:- its function is to turn the air hitting the end of the diffuser, so that air impacting on the lower end 31 of the diffuser tends to be turned with as little turbulence as possible, perpendicular to the sides of the diffuser. It is also important that the turning vane 32 does not reduce the wall area of the diffuser adjacent the end 31. Thus, the main requirement of the turning vane is that it provides a smoothly curved shape which provides a smooth transition for the impacting air.

Referring in particular to Figures 4 - 6 inclusive, substantially the whole of the wall of the diffuser 11 is formed with a plurality of holes 35 each of which extends right through the thickness of the wall, and each of which is circular or elliptical in plan and has the longitudinal axis of the hole inclined at an acute angle to both the radius and the longitudinal axis of the diffuser. In addition, each hole 35 is tapered along its length, with the wider portion of the hole at the exterior surface of the diffuser wall.

The tapering of the holes produces a Venturi effect, which creates a partial vacuum inside the diffuser and thus draws air down the drive shaft 10. Preferably, the total cross-sectional area of the outer diameter of the holes is of the order of four times the cross-sectional area of the drive shaft.

The angle of each hole 35 relative to the radius and to the longitudinal axis of the diffuser shown in detail in Figures 5 and 6, but it is emphasised that the precise angles shown in those figures are not critical, and are given by way of example only. The angles of inclination of each hole to the radius and to the longitudinal axis preferably approximate the resultant angle of the combined velocity of fluid going past the diffuser and the rotation of the diffuser, in use. However, it is believed that the rounded shape of each hole and the elliptical cross-section make it possible for the angles of inclination of each hole to vary from the ideal and still provide a diffuser which works very effectively.

In the preferred embodiment actually illustrated, Figure 5 shows the included angle a between the walls of the hole is about 30 degrees, and the angle of inclination **b** of the shorter wall to the longitudinal axis of the diffuser is about 60 degrees. As shown in Figure 6, the angle of inclination **c** between the shorter wall, the hole and the radius of the

diffuser is about 30 degrees.

The above described aerator/mixer operates as follows:- the aerator/mixer is suspended as shown in Figure 1, with the propeller 7 fully immersed in the liquid to be aerated/mixed, but with the ports 14 above the liquid. The electric motor 8 is operated to rotate the drive shaft 10, and hence the propeller 7 and diffuser 11, mixing the liquid. The mixing by itself provides a certain amount of aeration, but aeration is optimised by supplying pressurised air from the blower 17 through the pipe 16 and into the ports 14. The air then travels down the hollow interior of the drive shaft 10 into the diffuser 11, which rotates with the propeller and lies below the propeller.

As the diffuser rotates, a Venturi effect is created by the rotation of the diffuser and by the water stream created by the thrust of the propeller, which passes over the diffuser. As discussed above, the Venturi in the diffuser are orientated so that the resultant vector of the combined velocities maximises the Venturi effect.

The Venturi effect creates a pressure drop within the diffuser and a partial vacuum within the drive shaft. This reduces the load on the blower at the same time allowing more gas to enter the diffuser. Air which is drawn into the hollow interior of the drive shaft 10 can leave only via the holes in the diffuser. The air passing through the holes in the diffuser is exposed to a double shear action as it leaves:- firstly, the radial shear created by the rotation of the drive shaft, and secondly the linear shear from the water stream which is created by the thrust from the propeller. It is this double shear action which produces the desired small bubbles, which are interspersed by the rotating propeller in both vertical and horizontal vectors.

It will be appreciated that the air bubbles from the diffuser 11 enter the liquid below the propeller 7, and thus do not cause cavitation of the liquid.

Simply supplying additional pressurised air to the aerator does not provide efficient aeration:- the pressurised air would tend to enter the liquid in large bubbles, which are not effective aerators. The purpose of the diffuser 11 is to reduce the size of the bubbles being introduced into the liquid, so as to optimise aeration by maximising the surface area

of the bubbles per unit volume, which in turn maximises the oxygen/liquid interface. Further, the smaller the bubble size, the slower the bubble rise rate and therefore the greater the bubble "dwell time", i.e. the longer the bubbles are in contact with the liquid.

The above described aerator/mixer may be provided with a vortex shield (not shown) of known type. Typically, a vortex shield is a flat perforated plate which is rigidly suspended above the propeller in a plane substantially parallel to the plane of the liquid surface, but below the liquid surface. The vortex shield prevents a vortex from forming in the liquid above the propeller, and thus inhibits cavitation of the liquid, which would damage the propeller.

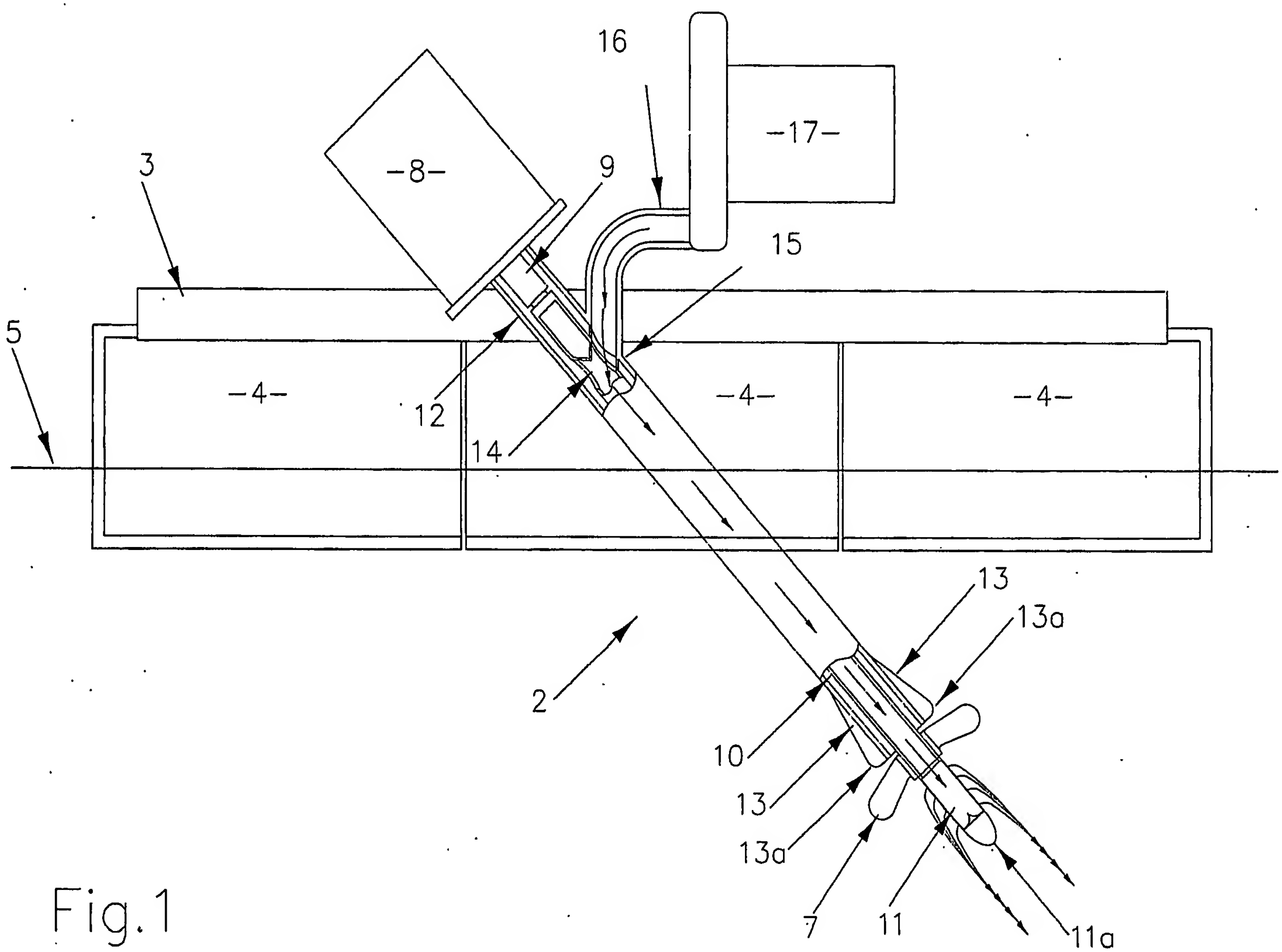
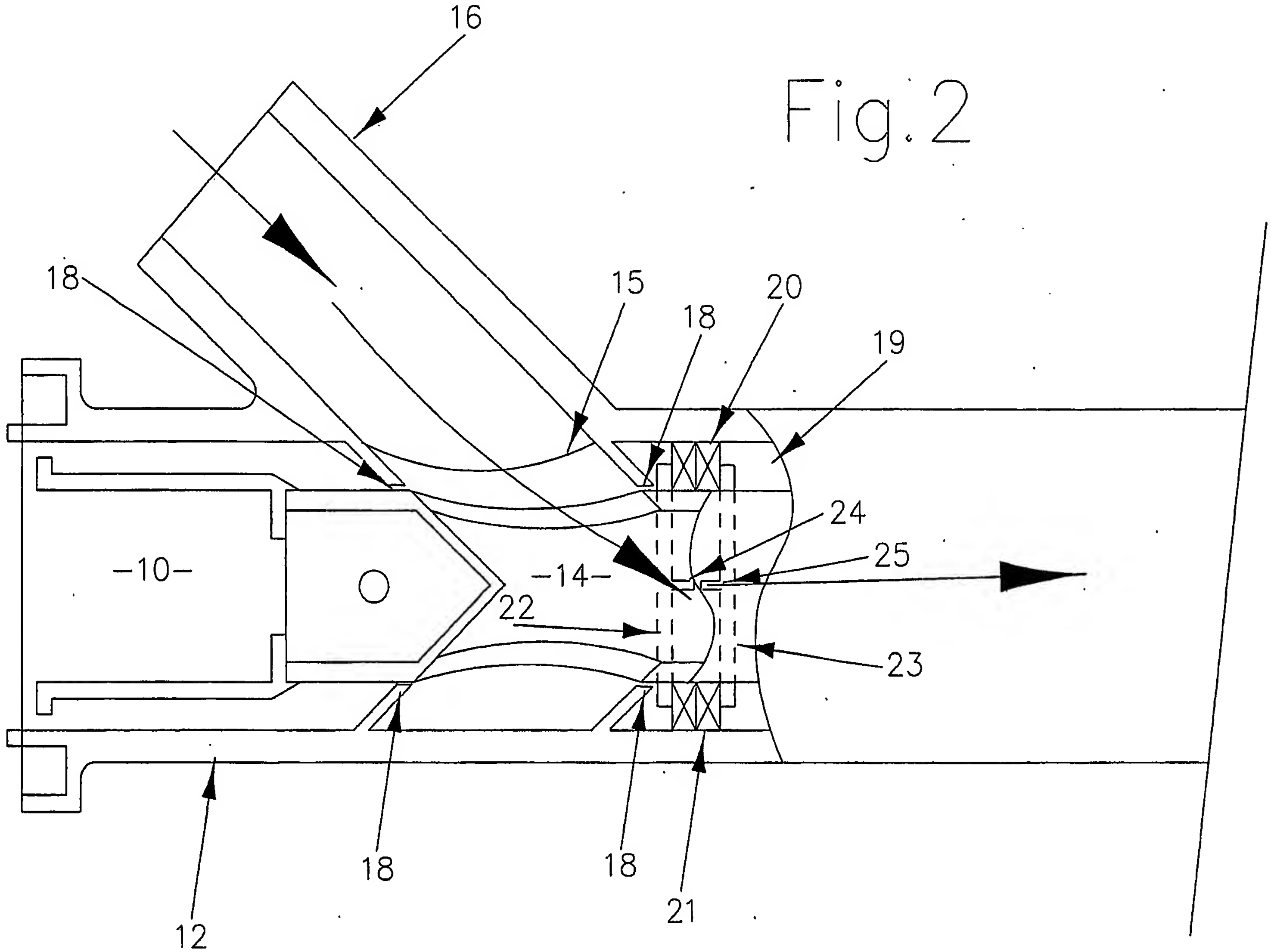


Fig.1

Fig. 2



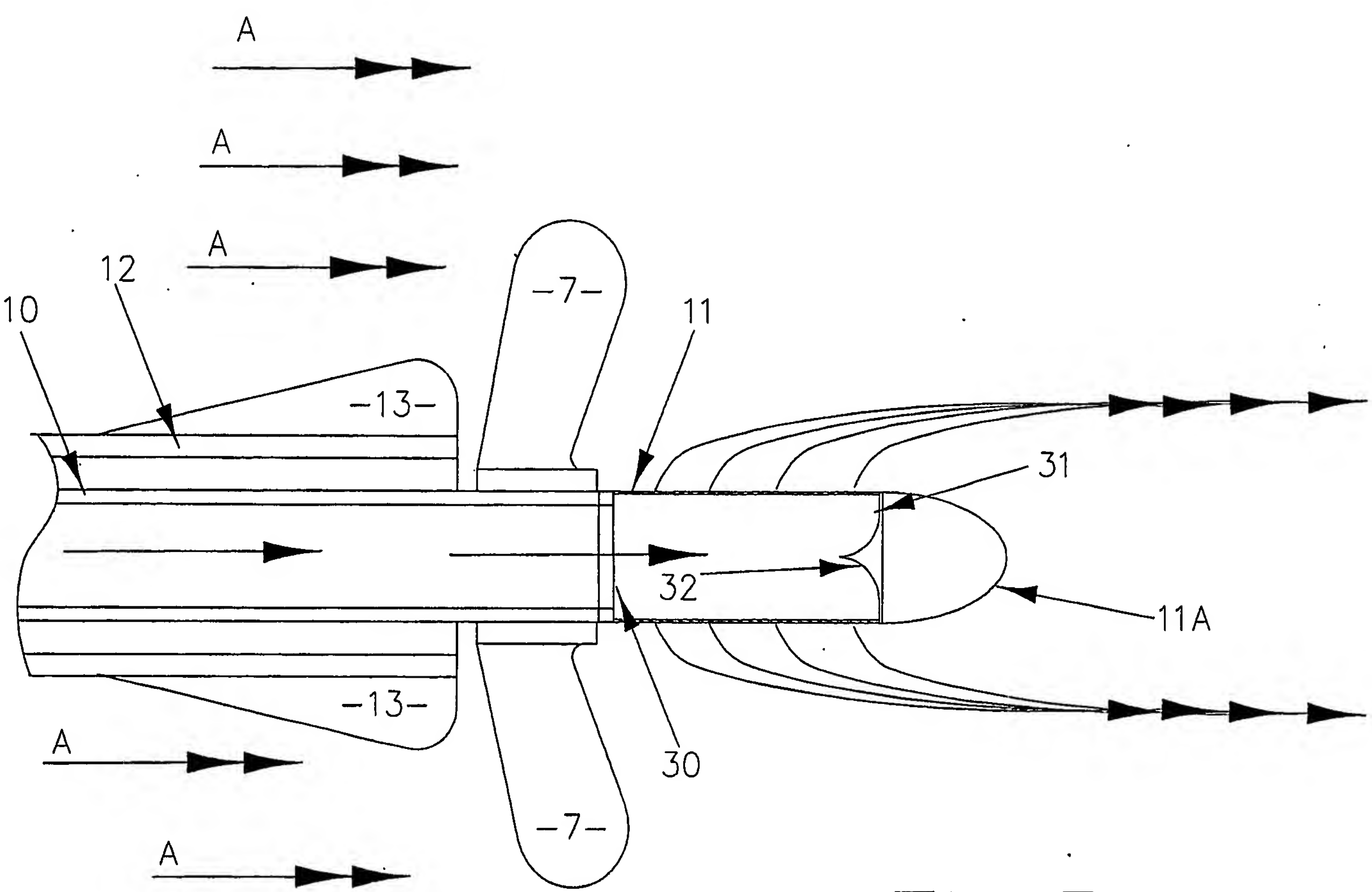


Fig. 3

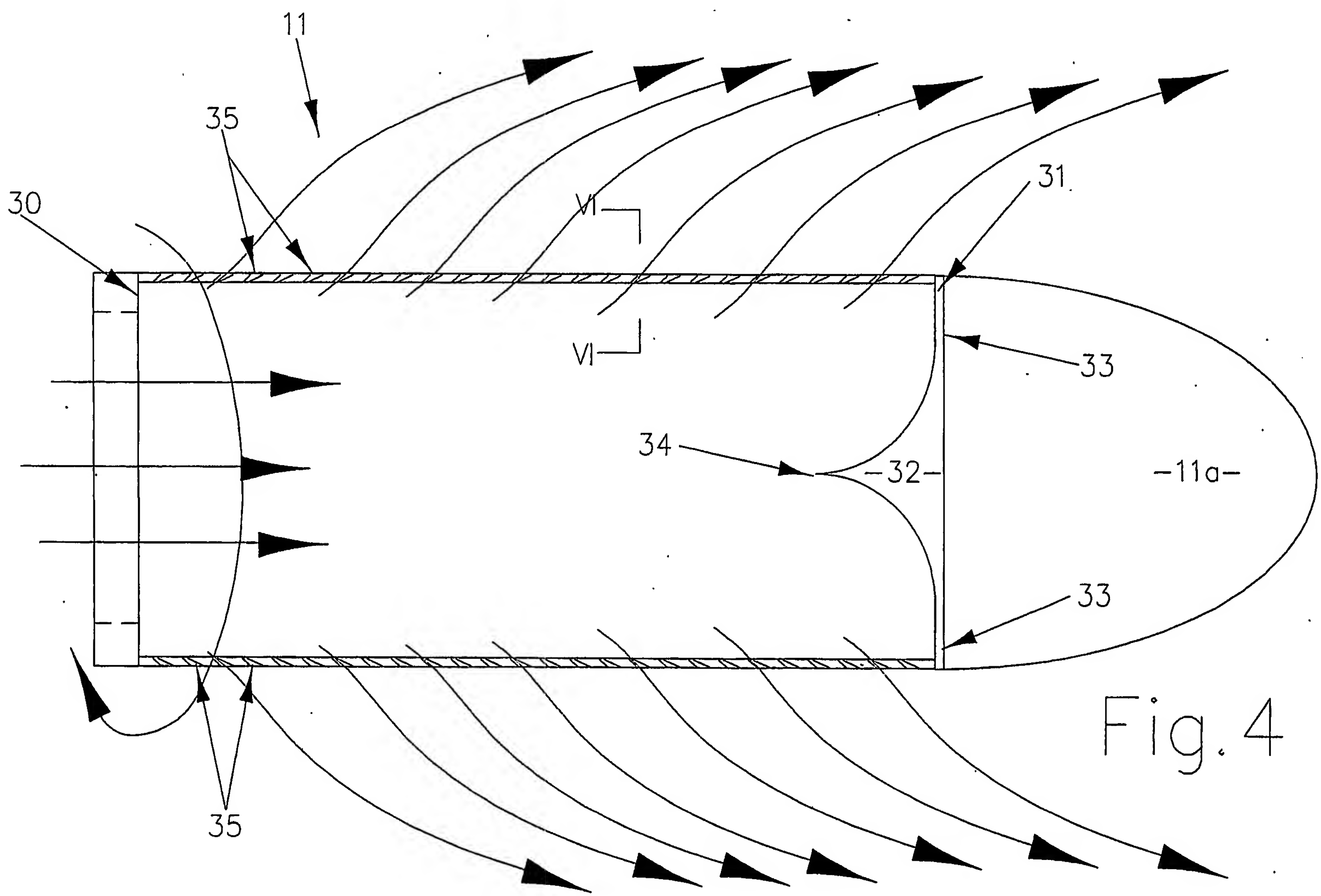


Fig. 4

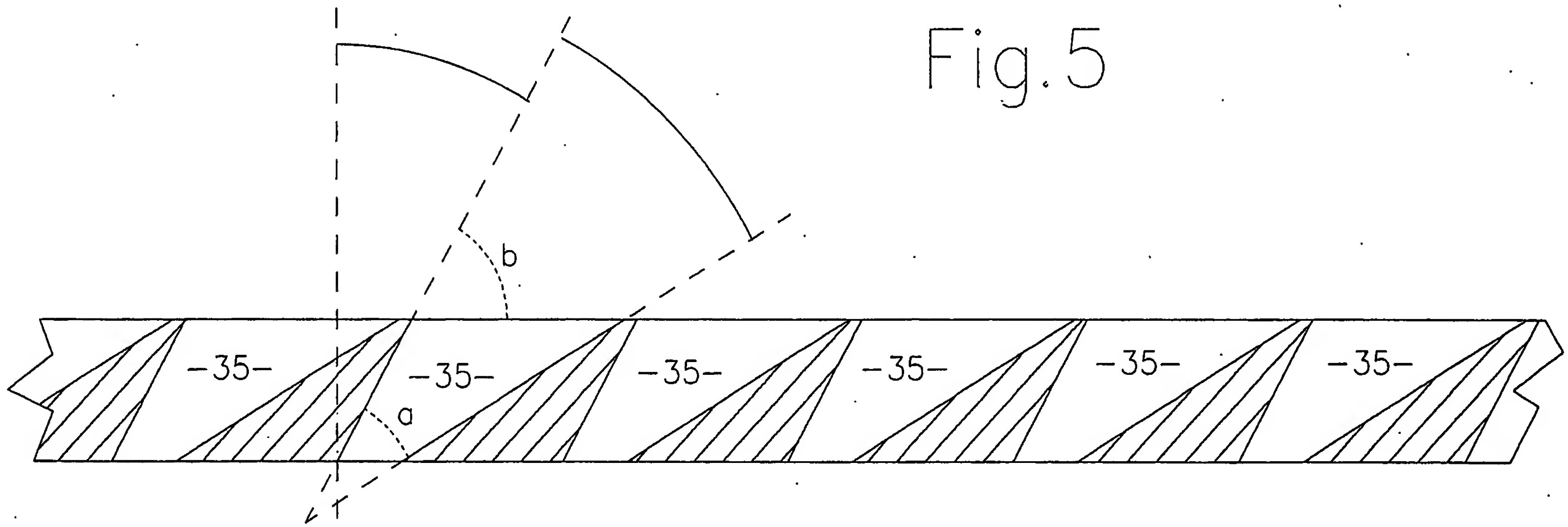


Fig.5

Fig.6